A Structural Equation Model of the Cost Effectiveness of Behavior Change Towards Diabetes Disease Management

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Abstract

Data were used from a Nashville (TN)-based disease management company to understand the behavioral aspect of managing diabetes. Diabetes disease management programs have been shown to be effective in managing diabetes, but behavior change along with disease management may be the key to maintaining the long-term, sustained, positive results necessary to reduce medical costs and hospitalization for diabetics. Three structural equation models were compared to determine the significance of the behavior change component in the management of diabetes. The Partial Mediation and Full Mediation Models included two manifest variables of Gender and Age, a Severity of Diabetes factor, a Self-Perception of Behavior Change factor, and an Outcomes factor based on health status, medical expenditure, and length of hospitalization. The No Behavior Effect Model only included the Age and Gender variables, and Outcome factor. Based on chi-square difference tests between the No Behavior Effect Model and the Partial Mediation Model, the Self-perception of Behavior Change factor was significant in explaining outcomes in diabetes disease management program. Due to the significant chi-square result between the Partial Mediation Model and Full Mediation Model, severity of diabetes, age, and gender along with the behavior component best explained outcomes in diabetics. A final model was found by taking the best fitting model (Partial Mediation Model) and making any significant changes recommended by the modification indices including adding any significant paths and deleting any nonsignificant variables or paths.

Acknowledgements

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Introduction

Diabetes is a steadily growing problem in the United States with an average of 16 million individuals in the United States (5.9% of the population) diagnosed as diabetic in 1998 (10.3 million diagnosed, 5.4 million undiagnosed). The prevalence of diabetes increased 33% in the 1990's with 798,000 new cases diagnosed each year. Diabetes is one of the 10 leading causes of death in the United States, making it the 6^{th} leading cause of death in the year 2000 resulting in 68,662 deaths. Diabetics accounted for 545,000 hospital discharges in 1999 with the average length of stay of 5.4 days. Additionally, diabetics were responsible for 19.6 million office visits in 1999. The total direct and indirect costs associated with diabetes in 1997 amounted to $98 billion with $44 billion associated with direct medical costs, and $54 billion associated with indirect costs (such as disability or work loss) (Center for Disease Control, n.d.).

History of Health care

During the 1970's and 1980's, health care costs were of little concern to health care providers; as compared today. Health care reimbursement was based on fee-for-service, and most individuals were paying for health care out-of-pocket, or with the aid of third-party payers (Cesta, Tahan, & Fink, 1998). Towards the mid-1980's medical costs were increasing while quality of health care and medical services were declining. Individuals and third-party payers were unwilling to accept the rising cost of health care, when quality of service was declining. This brought about ideas of change to reduce the cost of health care while increasing the quality of service. Individuals receiving these medical services as well as the health insurance companies and third-party payers were the interested parties in increasing the value of health care (Cesta, Tahan, & Fink, 1998).

The two major payment systems that were introduced at this time were diagnosis-related groups (DRGs) and health maintenance organizations (HMOs). It was the responsibility of these systems to reduce and control medical cost. The main idea behind DRGs was to provide hospitals and health care entities with financial incentives for keeping health costs down, through price-per-case reimbursement (Cesta et al., 1998).

HMOs are organizations that connect individuals with providers of medical services although the HMOs often have control over their members as well as the providers of these services (Birenbaum, 1997). Members are restricted to a certain list of providers, or physicians, and often cannot go directly to specialty physicians unless otherwise referred to them by their primary care provider. The only way members can go directly to specialty physicians is by accepting lower reimbursement rates, if any, offered by the HMOs or paying for the medical service out-of-pocket themselves. Physicians are contracted through the HMOs and have to offer their services at a set price determined by the HMOs. Additionally, physicians are encouraged to avoid any unnecessary costs for members such as excess lab tests, unnecessary prescriptions, or undue referrals to specialists. The physician's autonomy is restricted since he/she is encouraged to only provide the medical services that are absolutely necessary in an effort to control medical costs (Birenbaum, 1997).

Case Management vs. Disease Management

With the introduction of organized health care, membership enrollment has increased exponentially in the last ten years. Due to the rising costs of medical expenses and increased enrollment, HMOs are facing larger medical expenditures than ever before. To help control the costs for the HMOs and improve the quality of health care, case managers were introduced in the 1980's. The goal of case managers is to manage cost and quality of care while achieving positive patient outcomes through care coordination, facilitation, education, advocacy, discharge planning, resource management, and outcomes management. While managed care provides organized services through the provider on a prepayment plan, the case manager provides the structure to managed care to achieve the best possible outcomes including the most cost-effective steps involved for the HMOs while maintaining the best quality care for the patient (Cesta et al., 1998). Case managers are the vehicles through which managed care gets accomplished.

Case managers work on a one-to-one basis, between patient and physician, coordinating activities to find the best care for the most cost-effective outcome. Although case management may work well for certain situations, it may not be ideal for the whole population, especially when trying to reach larger populations to reduce medical expenditures and increase health. One such study that measured the effectiveness of case managers was conducted by the Diabetes Research Institute (Meneghini, Albisser, Goldberg, & Mintz, 1998). Diabetic individuals were given an "electronic case manager" (ECM) to report their blood glucose level daily. A case manager or physician would then make individual recommendations to each participant based on the reported levels. Although the number of sustained blood glucose levels increased and the number of reported cases of hyperglycemia and hypoglycemia reduced significantly, the amount of time and money spent to implement this type of program was phenomenal. At this time, the cost of running one ECM for only one diabetic patient was approximately $1000 per month. Consequently, for increasing sustained blood glucose level of only a few patients (in this study, 184 individuals), this type of case management procedure hardly seems worth the effort and high cost (Meneghini, Albisser, Goldberg & Mintz, 1998).

In order for HMOs to reach larger populations in hopes of reducing high costs of medical expenditure, disease management needs to be implemented and sustained to an HMO's entire population, especially for the chronically ill sub-populations. The idea of preventive intervention for health management organizations has become an essential component in controlling medical costs for their members as well as improving their member's health. In 1990, 45% of Americans had one or more chronic conditions, and the treatment of these chronic diseases accounted for three-fourths of the total health care expenditures in the United States (Birenbaum, 1997). With high medical expenditures, health management organizations will need their chronically ill sub-population to manage and control their disease(s), so that HMOs can financially survive, in addition to their members' physical survival.

According to the Disease Management Association of America (Disease Management Association of America, n.d.), disease management is a system of coordinated health care interventions and communications for populations with conditions in which patient self-care efforts are significant. Disease management:

- supports the physician or practitioner/patient relationship and plan of care,
- emphasizes prevention of exacerbations and complications utilizing evidence-

based practice guidelines and patient empowerment strategies, and

• evaluates clinical, humanistic, and economic outcomes on an ongoing basis with the goal of improving overall health.

Disease Management Components include:

• Population identification processes

• Evidence-based practice guidelines

• Collaborative practice models to include physician and support-service providers

• Patient self-management education (may include primary prevention, behavior modification programs, and compliance/surveillance)

• Process and outcomes measurement, evaluation, and management

• Routine reporting/feedback loop (may include communication with patient, physician, health plan and ancillary providers, and practice profiling).

A simpler definition of disease management is "an approach to patient care that coordinates medical resources for patients across the entire health care delivery system" (Ellrodt, Cook, Lee, Cho, Hunt, & Weingarten, 1997, p.1687). Here, the essential point of disease management is to provide high-quality care across the continuum of the disease, not just during one particular period of the disease.

Disease management is aimed at finding health care solutions for an entire population for particular chronic illnesses through the continuum of the disease so that individuals can manage their disease and take control of their health, thus decreasing the medical expenditures for the HMOs. Overall increased health for these individuals who manage their disease result in fewer emergency room visits, hospital visits, doctor visits, lab tests, and medications, overall saving HMOs large amounts in medical expenditures.

Classification of Diabetes

According to the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus (1999), diabetes mellitus is defined as “a group of metabolic diseases characterized by hyperglycemia resulting from defects in insulin secretion, insulin action, or both”. Diabetes can cause hyperglycemia (high blood sugar) or hypoglycemia (low blood sugar). Symptoms of high blood sugar include high levels of sugar in the urine, polyuria (frequent urination), and polydipsia (increased thirst) (American Diabetes Association, n.d.). Symptoms for low blood sugar in diabetics include shaking, sweating, headaches, tingling, hunger, blurred vision, dizziness and confusion, numbness of the lips, nausea or vomiting, fast heart rate, sudden tiredness, pale appearance, frequent sighing, personality change, confusion or poor concentration, seizures, or loss of consciousness (Diabetes Services, n.d.)

According to the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus, there are three criteria for the diagnosis of diabetes mellitus (1999). The first diagnosis of diabetes is “symptoms of diabetes plus causal plasma glucose concentration greater than or equal to 200 mg/dl (11.1 mmol/l). Casual is defined as any time of day without regard to time since last meal. The classic symptoms of diabetes include polyuria, polydipsia, and unexplained weight loss”. (p.S12)

The second criteria for diagnosis of diabetes is “fasting plasma glucose greater than or equal to 126 mg/dl (7.0 mmol/l). Fasting is defined as no caloric intake for at least eight hours." (p.S12) A fasting plasma glucose test will test the blood after the individual has fasted for at least 8 hours, and a normal fasting plasma glucose level is defined as less than 110 milligrams per deciliter (mg/dl) (American Diabetes Association, n.d.).

Finally, the third criterion for diagnosis of diabetes is "2 hour plasma glucose of greater than or equal to 200 mg/dl (11.1 mmol/l) during an oral glucose tolerance test. The test should be performed using a glucose load containing the equivalent of 75-g anhydrous glucose dissolved in water." (p.S12) As explained by the American Diabetes Association, an oral glucose tolerance test is performed after eight hours of fasting, with several measures of blood taken during a three hour period. The first sample of blood is taken after 8 to 16 hours of fasting, while the next four blood samples are drawn at different time periods after 75 grams of glucose is ingested. The five different blood samples measure the rate at which the body breaks down the glucose. For non-diabetes, glucose levels will rise and then quickly fall, while glucose levels for diabetics will rise higher than normal, and then fail to come back down (American Diabetes Association, n.d.).

Unfortunately, individuals with diabetes aren't solely responsible for managing their disease. There are several other complications that often occur due to diabetes. These complications include blindness due to diabetes retinopathy, kidney disease due to nephropathy, heart disease, strokes, high blood pressure, nerve disease and amputations due to diabetic nerve damage, dental disease, or impotence due to diabetic neuropathy or blood vessel blockage (American Diabetes Association, n.d.).

Costs Associated with Diabetes

Several studies have measured the health care expenditures for the diabetic population versus the nondiabetic population. These studies often used claims data from certain HMOs or national health care databases while looking at a diabetic population based on some criteria for inclusion.

Rubin, Altman, and Mendelson (1994) used 1987 data from the National Medical Expenditure Survey (NMES) to estimate total health care expenditures for the diabetic population in 1992. The diabetic population was identified by one of three criteria for inclusion: individuals who were taking insulin or some other diabetes-related medication, individuals who were given a diabetic label through International Classification of Diseases, Ninth Revision (ICD-9 codes) in the health care system, or individuals who had answered “yes” to the question “Has a doctor ever told you that you have diabetes (high blood sugar)?” on the NMES.

The results indicated that total U.S. health care expenditures in 1992 were $720.5 billion, with the diabetic population totaling $105.2 billion, or 14.6% of total U.S. health care expenditures (Rubin, Altman, & Mendelson, 1994). Per-capital annual health care expenditures for diabetics versus nondiabetics averaged $9,493 versus $2,912. The breakdown of medical expenditures for diabetics showed that inpatient hospital care accounted for 63% of total health care expenditures, followed by outpatient hospital care and office visits at 12% and 10%, respectively. Additional expenditures that contributed to health care expenditures for diabetics included emergency room visits (1%), drugs and durable medical equipment costs (9%), home health care (4%), and dental costs (1%).

Thus, 4.5% of the general population who had diabetes incurred health care costs 3.6-fold greater than the general population (Rubin et al., 1994).

Selby, Ray, Zhang, and Colby (1997) implemented a similar study to compare the medical costs of a diabetic population versus a nondiabetic population using health care expenditures of Kaiser Permanente Medical Care Program. The authors identified diabetic individuals from pharmacy prescriptions for diabetic medications, abnormal HbA_{1c} values from lab files, hospital discharge diagnoses of diabetes, or emergency room visits with physician diagnosis of diabetes. A nondiabetic population was randomly selected from the Kaiser Permanente Medical database to match similar demographic characteristics consisting of age, gender, and zip code distribution as well as size of the diabetic group. Each group consisted of 85,209 members from the Northern California area. The authors found that this particular HMO (Kaiser Permanente Medical Group) spent $282.7 million dollars more for the diabetic population in 1994 than the nondiabetic population. Thus, total health care expenditures were 2.4 times higher for diabetic patients than nondiabetic patients. A breakdown of the health care expenditures for this diabetic population showed $108,937,321 (38.5%) accounted for hospital visits, $79,506,326 (26.1%) accounted for outside referrals, and $26,603,573 (11.4%) accounted for pharmacy costs. Additional expenditures that attributed to total health care expenditures for diabetic patients included specialty outpatient (7.2%), primary care (6.8%), outside claims (5.6%), emergency care (2.8%), and nonphysician output (2.1%). The diabetic population, which accounted for 3.6% of the general population, accounted for 11.9% of the total health care expenditures in 1994. Compared to the results found by

Rubin, Altman, & Mendelson (1994) for the entire diabetes population of the U.S., the results for this diabetes sub-population in the Kaiser Permanente Medical Care Program found by Selby, Ray, Zhang, and Colby (1997) are very comparable in numbers.

The American Diabetes Association conducted a large, comprehensive study to determine the economic consequences of diabetes in 1997 (American Diabetes Association, 1998). The study looked at both the direct and indirect costs associated with diabetes. Medical expenditures attributable to diabetes taken from the National Health Care Survey data were used for measuring the direct cost of diabetes while days lost at work and foregone earnings due to disability taken from the Social Security Association were used to measure the indirect cost of diabetes.

Results indicated that 13.9 million hospital, 2.8 million hospital outpatient encounters, and 3.5 million emergency room visits were attributed to diabetic patients in 1997. Nursing home care for 192,383 nursing home diabetic patients accounted for 69.7 million days of nursing home care. Additionally, there were 30.3 million visits to the doctor and 108,680 ambulatory surgeries for diabetic patients in 1997.

Total health care expenditures in 1997 for diabetic patients totaled $44 billion in which $27.5 billion or 62.2% was spent on inpatient care. Nursing home care accounted for $5.5 billion (12.5%) and outpatient services totaled $11 billion (24.7%). Indirect costs associated with diabetes indicated that people with diabetes lost on average 8.3 days from work, while nondiabetics lost on average 1.7 days from work. This resulted in 88 million disability days lost in 1997 due to diabetes, accounting for $1.4 billion in lost wages.

Overall, in 1997, total medical expenditures due to inpatient, outpatient, and pharmaceutical expenditures for 7.5 million diabetics totaled $77.7 billion. Per person, diabetics averaged $10,071 in health care expenditures while nondiabetics averaged $2,669 in health care expenditures. Taking inflation into account, these findings are consistent with the 1994 results found by Rubin, Altman, and Mendelson (1994). The per person expenditures for diabetics in 1994 was $9,493 for diabetics versus $2,912 for nondiabetics found by Rubin et al. (1994), compared to $10,071 for diabetics versus $2669 for nondiabetics found by the American Diabetes Association in 1997.

It is apparent that there are several contributing factors to the high medical expenditures associated with insuring an individual with diabetes. All reports found that the highest expenditure of all medical expenditures for diabetic patients is hospitalization, followed by outpatient care, and then office visits or primary care. Other contributing factors include emergency room visits, drugs, home health, nursing home care, and durable medical equipment. Implementing disease management programs in an effort to influence diabetic patients to manage their disease is the best way to target the large diabetic population and thus seriously reduce these high medical expenditures. Healthier diabetic patients who make the lifestyle changes necessary to manage their own disease visit the hospitals and physician offices less often, and may eventually require fewer medications. This, in turn, will save individual HMOs millions of dollars (or billions of dollars for total health care costs nationwide) in medical expenditures each year.

Diabetes Disease Management

Disease management, for any type of disease, is the key element for reducing costs and ensuring future success of health care organizations. This in turn will positively affect the physical health of the individual. The important aspect of disease management consists of patient education about the physiological effects of their disease along with the associated complications, risks, and warning signs prevalent in a disease. Diabetes disease management programs provide individuals with knowledge about diabetes in an effort for individuals to monitor and control their disease as well as recognize any problems or complications associated with diabetes. Education for controlling diabetes include information about blood glucose monitoring, diet and exercise changes, recognition of symptoms of hypo- or hyperglycemia, and monitoring peripheral sensation changes (Donaldson, Rutledge & Pravikoff, 1999). Other exams that diabetics need to obtain on a yearly basis include regular foot exams, eye exams (to watch for retinotherapy), glycated hemoglobin exams (HbA_{1c}), ketone testing, lipid testing, and testing for microalbuminuria (Chang, 2001).

The reported success of diabetes disease management programs has varied. Most studies have defined success of these programs through changes in measured variables (such as decrease in HbA_{1c}), increase in compliance to obtaining yearly exams (such as increase in compliance to eye or foot exams), decrease in utilization (such as decrease in utilizing hospitals or outpatient care), or through decrease in costs for associated medical expenditures for diabetics.

One such study that looked at the change in measured variables was conducted by the Diabetes Care Center in Connecticut (Abourizk, O'Connor, Crabtree, & Schnatz, 1994). This study researched the effect of a 4-day outpatient program that evaluated, treated, and gave individual sessions on meal selection, podiatry care, and follow-up. Glycated hemoglobin assay (HbA_{1c}) measures as well as measures on knowledge of diabetes, health locus of control, and functional health status were taken before the start of the program and at 2, 4, 8 and 12 months after the program. Results indicated that HbA_{1c} levels were the only significant change from baseline out of all measures. The glycated hemoglobin assay (HbA_{1c}) decreased from 9.97% to 7.53% at 12-month follow-up. No other measures showed any significant changes.

Rubin, Dietrich, and Hawk (1998), looked at clinical and financial data at baseline and a one-year follow-up period after implementing a comprehensive health care management program called Diabetes Netcare. Results indicated that compliance levels for four types of exams increased: compliance to yearly glycated hemoglobin (HbA_{1c}) tests rose from 34% to 76%, compliance to eye exam rose from 23% to 40%, compliance to foot exam rose from 2% to 25%, and compliance to cholesterol test rose from 39% to 63%. The average glycated hemoglobin test for those individuals who received at least two HbA_{1c} tests fell from 8.9% to 8.5%. Also, hospital admission per 1,000 diabetic member years decreased from 289 to 196 in follow-up period. For the economic consequences of this diabetic program, total costs decreased by $44 per diabetic member per month (PDMPM), which results in savings of $528,000 for the first year of operation. Most of this decrease in costs was due to decrease in hospitalization stay. The major contribution of this study was the inclusion of medical expenditures as one of the observed variables.

Looking at the effectiveness of different types of diabetes education programs, Campbell, Redman, Moffitt, & Sanson-Fisher (1996), compared four different diabetes educational programs that had various levels of educational involvement. The minimal program consisted of two 1-hour education sessions, the individual education program consisted of two initial sessions with monthly follow-up sessions for 12 months, the group education program consisted of two individual sessions and a 3-day small group education course, and the behavioral program consisted of three individual visits from a nurse educator in the first month, along with subsequent visits dependent upon individual needs. The patients in this group were given a risk-factor appraisal, and then cognitive-behavioral techniques were used to change their eating, exercise, and smoking habits. The measures that were collected at baseline, and at 3, 6, and 12 months included blood glucose levels, diabetes treatment (type and dose of medication), body mass index (BMI), blood lipids, blood pressure, cholesterol level, diabetes knowledge, and a self-report item on smoking. The results indicated that there were no significant differences between programs for HbA_{1c}, BMI, total cholesterol, blood lipids, or blood pressure. There were slight differences between some of the programs for the remaining measures, but none of the remaining findings were pertinent towards the management and control of diabetes.

The largest decrease, thus far, in medical expenditures from a diabetic population came from a study conducted by a Nashville based disease management company specializing in diabetes (American Healthways, 1999). After stratifying diabetic members and determining the necessary intensity of support and services, a patient care manager worked with the individual and their primary care physician. Results found that total health care costs decreased by $114 per diabetes member per month (PDMPM), or a decrease of 17.1%. Hospitalization accounted for the largest portion of decrease in costs at $54.47 PDMPM (or 15.9% decrease in hospitalization). But, for individuals who continuously participated in the program for the full year, costs decreased by $125 PDMPM, or 21.2%, with hospitalization accounting for $67.91 (or 23.7% decrease in hospitalization). Compliance to receiving at least one glycosylated hemoglobin (A_{1c}) test in one year rose from 61% to 74% for the entire population, while compliance rates rose 74% to 88% for those diabetic individuals who participated in the program for the full year. Compliance rates for eye exams, foot exams, serum creatinine test, and cholesterol screening also rose dramatically after diabetics participated in the program. Finally, A_{1c} values decreased from 7.81% to 7.52% for those who had at least three glycosylated hemoglobin tests in one year, from 7.93% to 7.41% for those who had at least four glycosylated hemoglobin tests in one year, and from 7.75% to 7.48% for the entire sample at baseline to one year follow-up.

Diabetes is a serious, chronic illness that has resulted in many unnecessary deaths due to complications or lack of management and control of their disease. Diabetes requires complete lifestyle changes that involve diet changes, exercise, and constant monitoring of blood glucose levels, including watching for symptoms of hypo and hyperglycemia. Diabetes disease management programs have helped with these changes, but their success has varied.

Risk Stratification of Diabetes

Grouping diabetics into one category may not be the best way to understand this diseased population. Breaking up the diabetic population based on risk stratification and level of severity of diabetes may be a better way to understand the diabetic population as well as a better way to reach and educate the diabetic population through tailored diabetes disease management programs. For example, higher risk diabetics with more health problems and complications may need a more intense type of diabetes management program to control their diabetes while individuals with little risk may need a less intense program that requires only few changes to control their diabetes.

To understand the utilization of hospitalization associated with different levels of severity of diabetes, Gonnella, Hornbrook, and Louis (1984) classified diabetics into different "stages" based on the severity and risk of the disease. Specifically, they were interested in finding the frequency of each stage as well as the utilization (length of stay in hospital) associated with each stage. The four different stages, each with several substages, include the diagnosis of diabetes, and higher stages are associated with more complications, symptoms, and risk than lower stages. The results indicated that diabetics classified in higher stages were individuals that were older and required more care. Specifically, age increased with each stage increase (so that higher stages had higher frequency of older individuals), and length of stay in the hospital increased with each stage increase (average of 9.17 days for stage 1 versus 12.84 days for stage 4). Also, within each stage, average length of stay increased as age increased. Classifying diabetics into stages indicates that the higher the stage, the older the individual, the longer the hospital visits, the more care that is required, which results in higher medical expenditures for the health care companies. Using a classification scheme to categorize diabetics based on risk and severity of disease is a useful means of understanding who comprise the high-risk members that require more care, and acquires higher medical expenditures.

Clark, Snyder, Meek, Stutz, & Parkin (2001) investigated the effect of disease management programs that were tailored to diabetics based on their risk stratification level. The disease management program was implemented in several phases: enrollment, initial encounter, risk stratification and action planning, intervention, patient education, interim visits, and follow-up visits. Risk stratification categories were divided into low, medium, and high, and were based off seven criteria: glycemic control, cardio-vascular disease, nephropathy, retinopathy, hyper/hypoglycemia, amputation, and psychosocial disorders. Risk profile reports based off the risk stratification categories were printed off for each individual and their physician, which included a tailored intervention protocol. To measure the success of the program, several measures were taken before the start of the program and at a 12-month follow up, which included glycated hemoglobin assay (HbA_{1C}), blood pressure, and lipids. Results indicated that the number of patients in the low risk category ($HbA_{1C}<7\%$) increased 51.1% from 47 members at baseline to 71 members after 12 months. The number of patients in the moderate category ($7\%<HbA_{1C}<8\%$) increased by 2.5%, from 70 members at baseline to 74 members after 12 months. Lastly, the number of patients in the high-risk category ($HbA_{1C}\geq8\%$) decreased by 58.3% from 76 patients at baseline to 48 members after 12 months. The number of individuals with lower blood pressure also increased for these groups: blood pressure readings <140/90 mmHg increased from 38.9% at baseline to 66.8% at 12-month follow up and blood pressure readings <130/85 mmHg increased from 22.8% at baseline to 44.6% at 12-month follow-up. Compliance levels for all patients rose as well: lipid testing increased from 66% to 100%, microalbuminuria testing increased from 17% to 100%, foot exams increased from 0% to 100%, and dilated eye exams increased from 53.9% to 80.3%. Finally, the percentage of individuals at high risk for coronary heart disease (LDL>130 mg/dl) decreased from 25.4% to 20.2% over the 12-month period. By tailoring disease management programs to diabetics based on their risk stratification level, intervention has found significant decreases in glycated hemoglobin assays as well as increases in compliance levels to receiving the necessary yearly exams, increases in lower levels of blood pressure, and decreases in the number of individuals at high risk for coronary heart disease. It is evident that the risk stratification method is an effective way to treat the diabetic population.

Behavior Change Component

Although disease management programs have shown to be effective in managing diabetes and classifying diabetics based on severity of their disease has shown to be successful, the results of treating diabetes and maintaining a diabetes regimen may not be sustained and long-term. Behavior change along with education has been shown to be the most effective way to achieve positive, sustained, long-term results in managing diabetes for a large diabetes population (Clement, 1995). Because controlling diabetes requires such lifestyle changes, complete behavior changes towards managing diabetes may be the key to these long-term results. Individuals who change their behaviors to manage their disease on a daily basis live healthier lifestyles, which amounts to fewer complications, hospital visits, outpatient care, and doctor visits, and can lead to tremendous decreases in medical expenditures associated with diabetes. Measuring this behavioral change aspect in relation to patient education for a diabetes disease management program is a fairly new concept that is slowly gaining recognition. Only a few published studies exist that measure and explain this behavioral change component in the management of diabetes.

The most basic of models is proposed by Glasgow (1995), which consists of a practical model of diabetes management and education (See Figure 1). This conceptual model is composed of three levels: level I is the background, environmental and context factors, level II is the cycle of care and medical intervention, and level III is the follow-up outcomes and major societal costs/benefits. Each level then comprises several sub-levels. Level I includes community and social context, patient characteristics, and clinic and program characteristics. Level II includes patient-health care team interactions, self-management behaviors, and short-term physiologic outcomes. Level III includes long-term health outcomes and quality of life. Not only does this model include some of the basic factors of diabetes such as demographic variables and social support from family, but it also encompasses some distinct variables that have not been included in the past, such as self-management behaviors and program characteristics. However, this model is only a conceptual model without any empirical data to support the schema.

Nowacek, O'Malley, Anderson, and Richards (1990) have proposed a more specific model of diabetes self-care management (See Figure 2). Based on a structural equation model, the model includes two exogenous variables: Socioeconomic Status

Figure 1. Glasgow's Practical model of diabetes management and education.

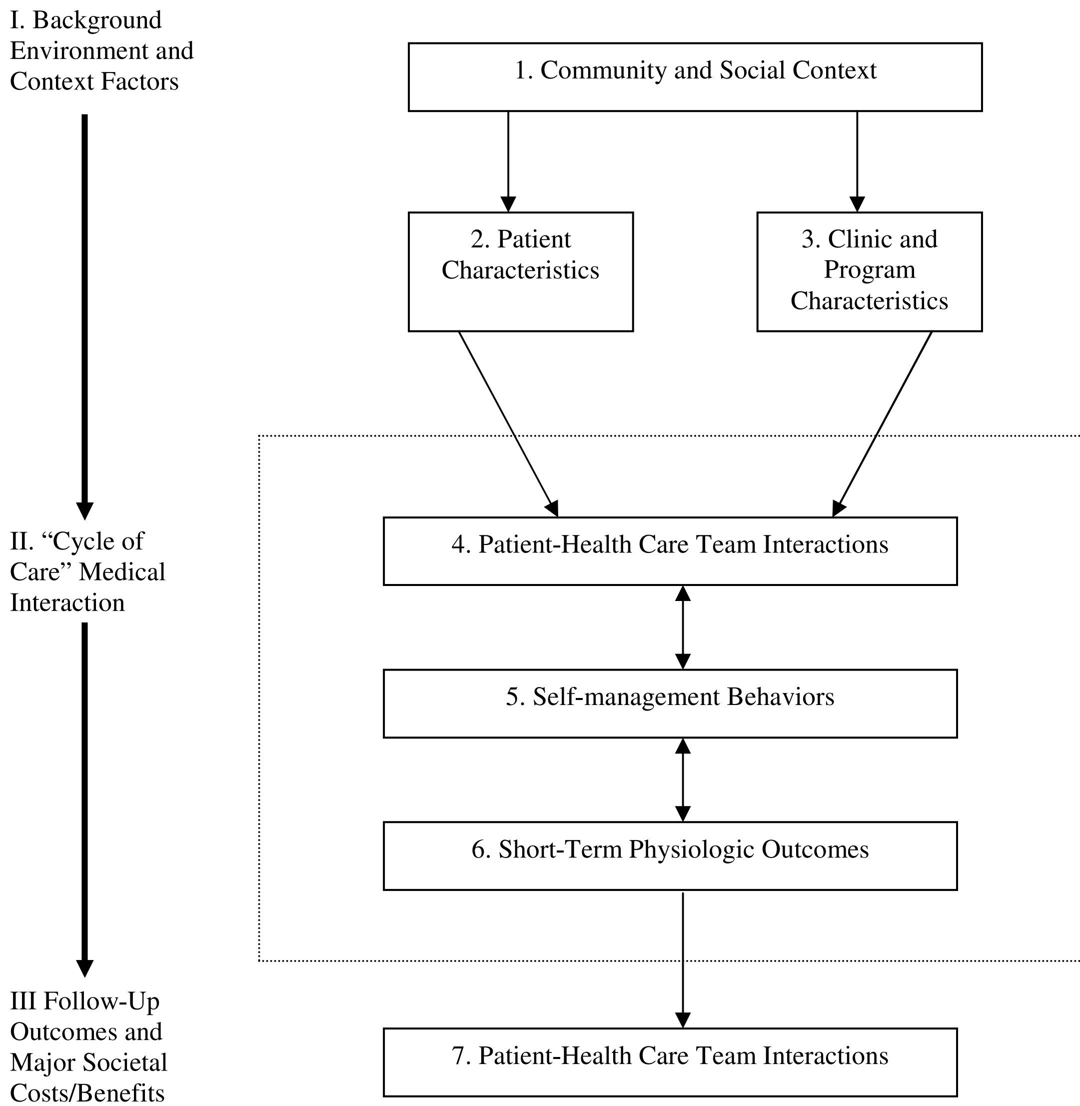
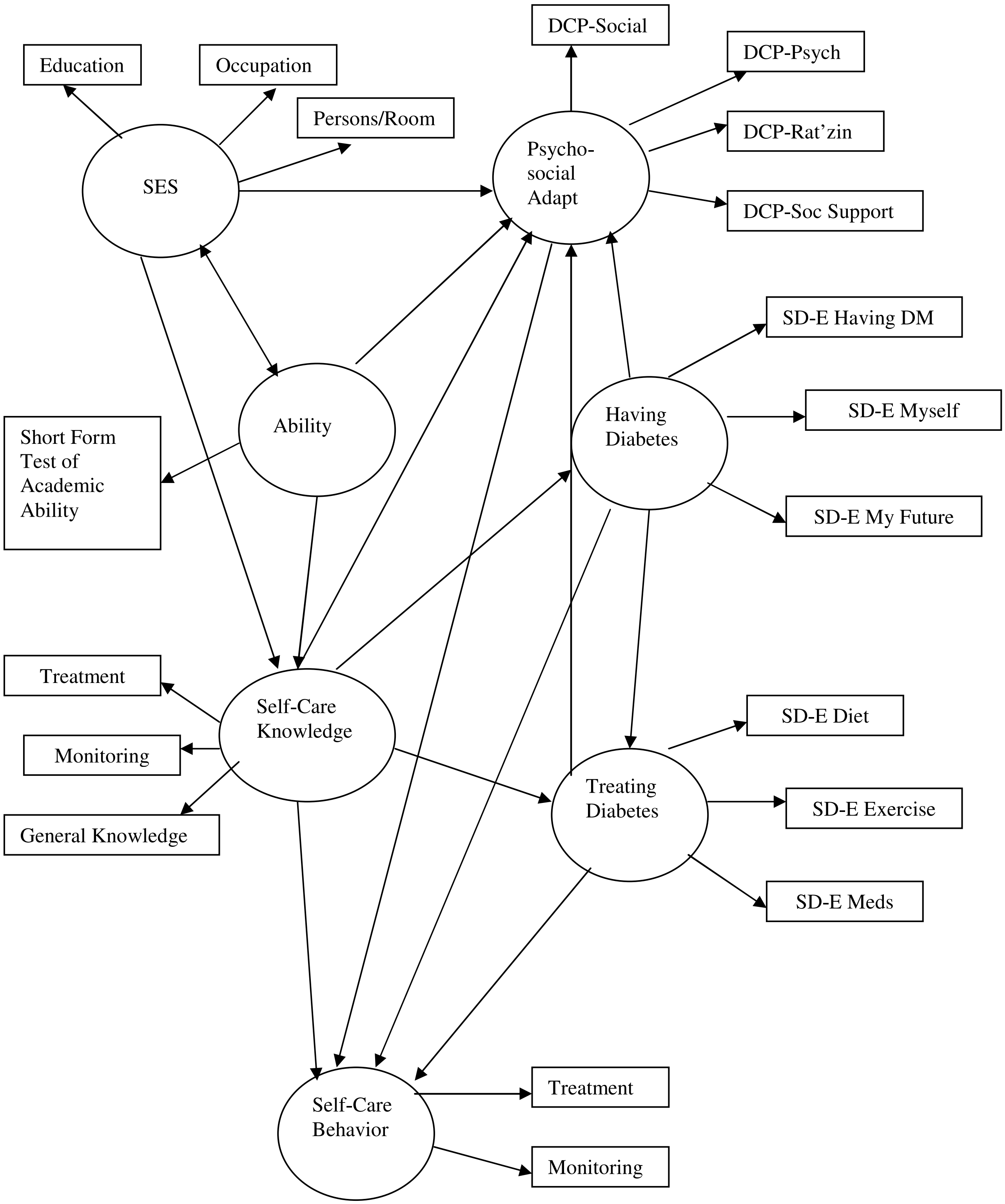


Figure 2. Nowacek, O'Malley, Anderson, and Richards' Model of Diabetes Self-Care Management.



(SES) and Ability variables. SES was measured by education and occupation and Ability was measured by the short form test of academic ability. The endogenous variables include Psychosocial Adaptation, Self-care Knowledge, Having Diabetes, Treating Diabetes, and Self-care Behavior. The Self-care Knowledge factor is related to the knowledge necessary for diabetes management. The Having Diabetes factor refers to the effects of the disease on the individual, while the Treating Diabetes factor refers to the affective component of the daily management routines of treating diabetes. Psychosocial Adaptation includes the psychosocial adjustment necessary for a person with diabetes. Finally, the Self-care Behavior factor is the degree to which the daily diabetes regimen is followed. Using a structural equation model, they found an overall fit of the model to be .846, and a root mean square residual of .074. Although the fit of the model was not great, this complicated model made a significant contribution to the field in that it explained diabetes self-care management by using some specific latent variables that have not been explored in the past.

Purpose of this study

In the past, most studies have focused on the effectiveness of different types of disease management programs through the measurement of various types of quantitative variables such as changes in compliance levels, changes in financial levels, changes in clinical measures, or changes in utilization (of hospitals and physician visits). Exploring the behavioral aspect of the management of a disease has not been well established. Based on the studies by Glasgow (1995) and Nowacek, O'Malley, Anderson, and Richards (1990), it is speculated that the behavior change factor may be the key to successfully implementing a disease management program and receiving positive, sustained, and long-term desired results for controlling diabetes.

One way of assessing and understanding the relationship between diabetes disease management programs, behavior change, and control of diabetes to help reduce hospitalization and medical expenditures while increasing overall health status is through the use of structural equation models as has been seen by some previous studies. By discerning the relationship among diabetes-related variables, we may find ways to control and/or explain the symptoms of diabetes. A structural equation model may help us understand the relationship among the observed diabetes-related variables as well as reveal any hidden, latent variables that may be the key to understanding and controlling diabetes and the behavior necessary to control the disease.

Utilizing structural equation modeling, Nagel (2001) proposed three models to explain the relationship between depression, perceived threat of diabetes, perceived social support, and demographic variables. Four subscales were used from the Interpersonal Support Evaluation List (ISEL), which included Appraisal, Belonging, Self-Esteem, and Tangible to measure the Social Support factor. The Primary Care Evaluation of Mental Disorders (PRIME-MD) and Mental Health (MD) subscale of the 36-Item Short-Form Health Survey (SF-36) were used to measure the Depression factor. Social role functioning (SF) and physical role functioning (RF) subscales from the SF-36 along with the Problem Areas in Diabetes Survey (PAID) were used to measure the Threat of Diabetes construct. The demographic variables of interest included age, marital status, education, and diabetes duration. Basically, all three models are similar except for a change in directional paths between the factors, and the third model even includes a reciprocal path between Threat of Diabetes and Depression.

To investigate this behavioral aspect of disease management, a structural equation model was adopted for this study based on studies by Glasgow (1995), Nagel (2001), and Nowacek, O'Malley, Anderson, and Richards (1990). Three models were developed and compared based on different relationships between the observed and latent variables. Statistical comparison among the three models revealed if this behavioral component to disease management helps in controlling diabetes by reducing hospitalization and medical expenditures while increasing overall health status as well as explain the relationship among the diabetes-related observed variables and latent factors. To reveal the best model, a chi-square difference test was used between two models at a time. If the chi-square was significant, than those two models were significantly different, and the goodness-of-fit index revealed the better of the two models.

Behavior Change Model

The proposed Behavior Change Model consists of three latent factors and two manifest variables. The two manifest variables are age and gender. It is evident that the condition of diabetes becomes more severe with age (Gonnella, Hornbrook, & Louis, 1984). The first latent factor, Severity of Diabetes factor, contains member months, risk stratification level (strat level), and care call count. The member months variable indicates how long diabetics have been enrolled in the diabetes disease management program, the risk stratification variable refers to the risk level their diabetes is ranked at on a level of one to four (with four being at higher risk), and the care call count variable is the number of care calls received from a trained nurse. The Self-Perception of Behavior Change factor consists of eight items from the Self-Perception of Behavior Change survey (Perry, 2001, see Appendix 1). Finally, the Outcome factor incorporates length of stay in hospital, overall health status, and total amount paid in medical expenditures.

All three models use some combination of the observed diabetes-related variables and latent factors. The Full Mediation Model contains the Self-perception of Behavior Change factor, which is influenced by Severity of Diabetes, as well as by age and gender manifest variables. The Self-Perception of Behavior Change factor then influences the Outcome factor of medical expenditures, hospitalization, and health status (See Figure 3). The Partial Mediation Model builds from the Full Mediation Model by the influence of the age and gender manifest variables and Severity of Diabetes factor on the Outcome factor in addition to the Self-perception of Behavior Change factor (See Figure 4). Finally, the No Behavior Effect Model eliminates the Self-perception of Behavior Change factor completely, leaving the Outcome factor to be influenced by the Severity of Diabetes factor and age and gender manifest variables (See Figure 5).

Most previous studies containing structural equation models on diabetes disease management and these three proposed models have the behavioral change component in common. Although previous studies used different measured variables, and different latent factors were revealed, all models are trying to expose this behavioral change component that may be the key to understanding the management of diabetes.

Comparing the three proposed models to previously discovered models,

Figure 3. Full Mediation Model.

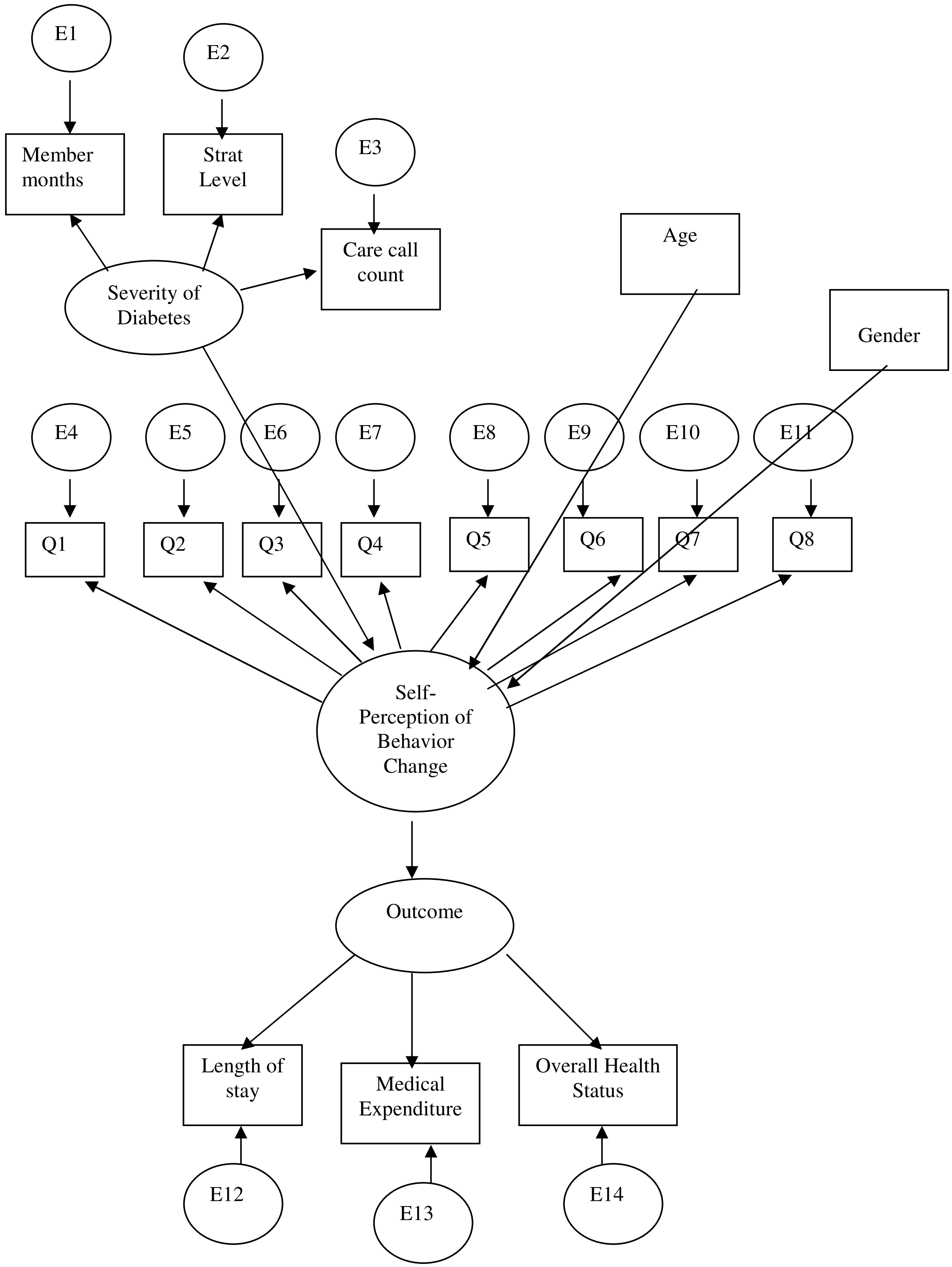


Figure 4. Partial Mediation Model.

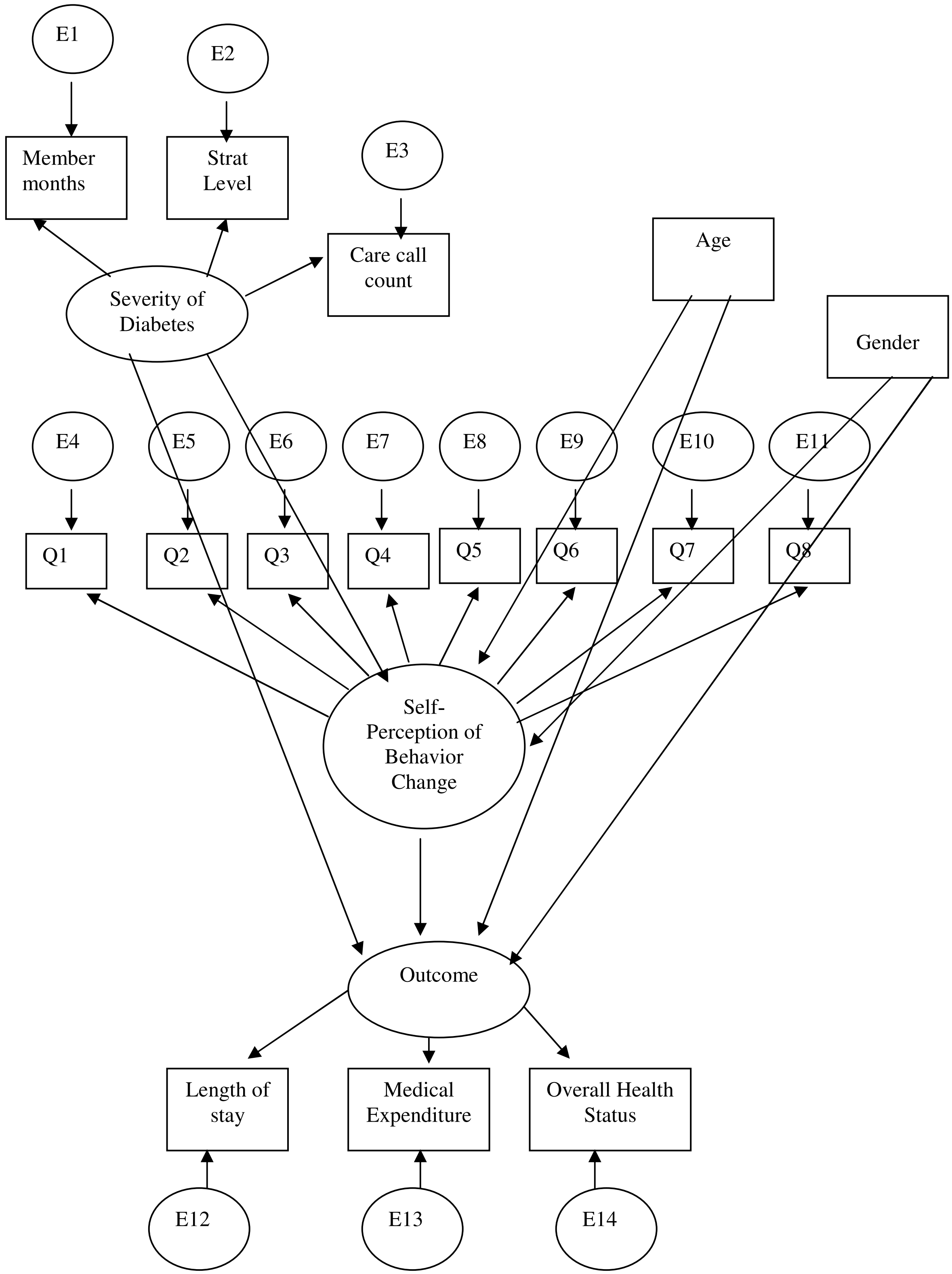
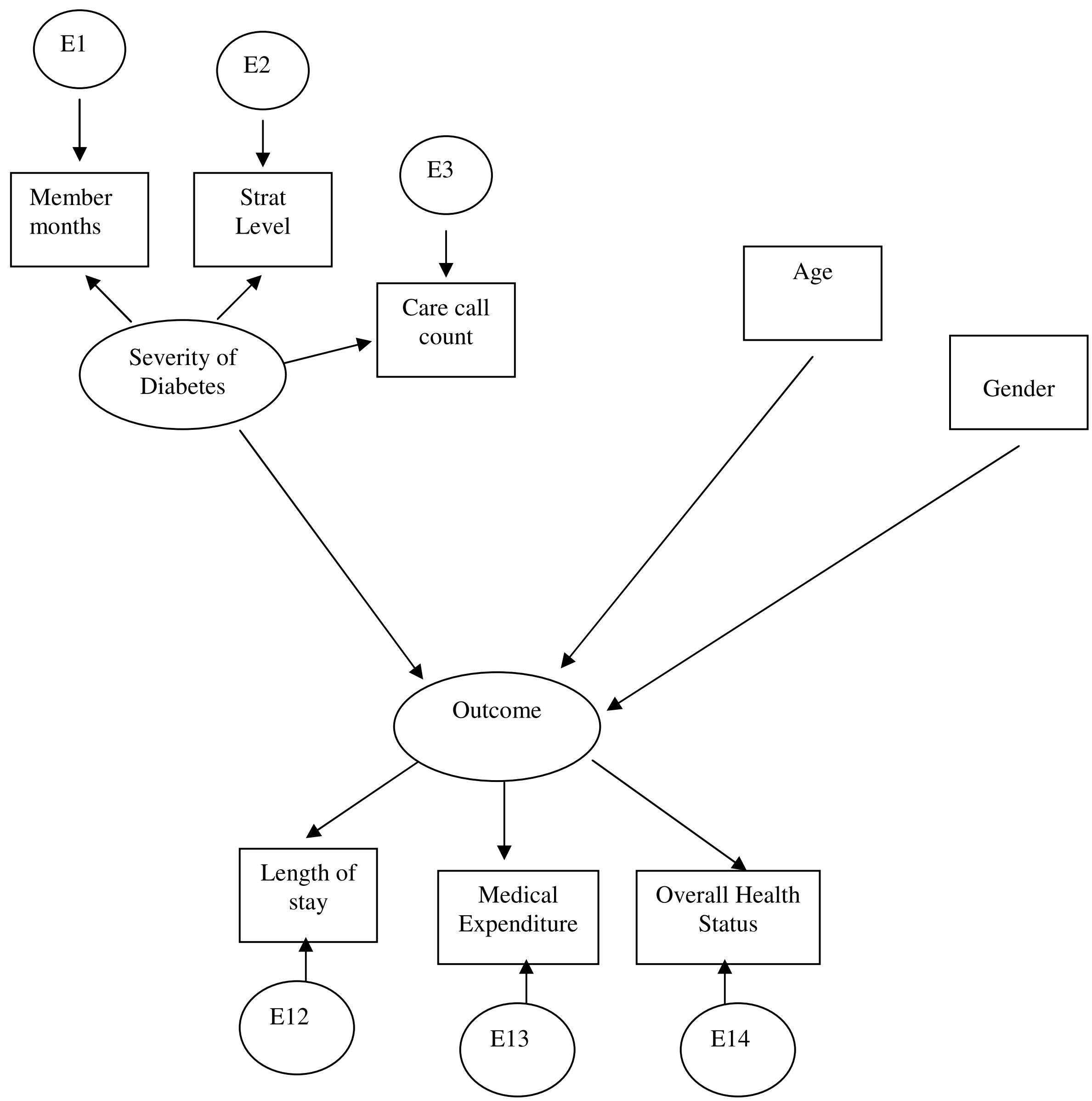


Figure 5. No Behavior Effect Model.



Glasgow's (1995) conceptual model contained patient characteristics that are also evident in these three proposed models, which includes demographics, medical history, and severity of disease. Also, the Self-management Behavior factor is exactly like the behavior change aspect that these models are trying to uncover. Glasgow proposes that all these factors should be taken together to understand the long-term health outcomes and quality of life aspect, which involves length of stay in hospital, accumulated medical expenditures, and overall health status in the proposed models. Overall health status could be considered the quality of life factor proposed by Glasgow. In the model of diabetes self-care management proposed by Nowacek et al. (1990), the Self-care Knowledge and Self-care Behavior factors correspond to the Self-perception of Behavior Change factor proposed in the Full Mediation and Partial Mediation Models. Their use of a structural equation model to understand the behavioral component of managing diabetes is the exact same goal of these proposed models.

Although these previous studies do not use all the same exact measured variables, the goal of all models are the same: to explain the management of diabetes through the use of different types of observed, measurable variables. All models are trying to uncover and identify what is important for controlling diabetes through the use of structural equation models.

Method

Subjects

An archival data set was obtained from a Nashville (TN)-based disease management company on individuals with a diagnosis of diabetes only (no cardiac problems) who completed the Self-perception of Behavior Change survey (See Appendix 1). All data were completely confidential with no identification of subjects. Age range for this sample was from 18 to 93 years old with a sample size of 748 diabetic individuals. Data were obtained from the base year of one year before the start of the program (1998/1999) as well as during the duration of the program, which consists of an 18-month time span (between 6/11/2000 and 10/30/2001). There is no missing data for any of the diabetic individuals. The final sample size for analyzing the models consisted of 496 diabetic individuals. Any individuals with as response of 1 (Not applicable or Don't Know) to any of the 8 items on the Self-perception of Behavior Change survey were eliminated, since the response of 1 weakened the factor loadings of the 8 items to the Self-Perception of Behavior Change factor in the model.

Data consisted of the answers to the two questionnaires, the General Health Assessment (GHA) and the Self-perception of Behavior Change Survey (Perry, 2001) as well as any associated medical claims submitted during the 18-month period for this diabetic sample. One question in particular was used from the GHA pertaining to the overall health status of the individual, answered after remaining in the diabetes management program for a specific time period. Information used from the medical claims included length of stay in hospital, amount paid by insurance company for each diabetic individual, number of months enrolled in the disease management program (member months), number of care calls received, and current risk stratification level (strat level).

To measure the perceived behavioral change aspect of individuals in the diabetes disease management program, members must have been continuously enrolled in the disease management program (between 6/1/2000 and 10/30/2001), and must have received at least one Care Call.

Measures

The two surveys include the General Health Assessment (GHA) and an 8-item Self-perception of Behavior Change Survey (SPBC). The GHA measures general health including questions in areas concerning general health, personal history, lifestyle, risk assessment, pregnancy assessment, and satisfaction with care and is based on a 5-point Likert-type scale (5-excellent, 4-very good, 3-good, 2-fair, and 1-poor). The only question that was used for this analysis pertains to the overall health status taken at the most recent time. The SPBC survey measures members' self-perception of their behavior change by addressing key areas of behavior change such as improving eating habits and taking medication, increasing physical activity, increasing discussing medical condition with their doctor, improving adherence to receiving appropriate medical tests, and spending less time worrying about their medical condition. Answers for the SPBC survey were also based on a 5-point Likert-type scale (1-Not applicable or Don't Know, 2-Not at all, 3-Somewhat, 4-Moderately, 5-A lot).

Procedure

This Nashville (TN)-based disease management company works with health care companies to enroll members into a diabetes disease management program. All members receive an introduction letter, welcome kit, scheduled outbound "care call" by specially trained nurses, inbound member calls through a hot line, periodic reminder cards, and newsletter mailings. Care calls are outbound personal communication performed by specially trained nurses with the goal of reinforcing positive self-management behaviors such as taking medications, checking blood sugar levels, and getting appropriate medical tests. Diabetic members are stratified into one of four risk levels based on a clinical stratification matrix using clinical variables to determine the frequency and intensity of intervention (i.e., frequency of outbound care calls received). Members in level 1 are the healthiest diabetic individuals, showing little or no risk of health compromise, and practicing self-care behaviors towards their disease. Members in levels 2 through 4 have increasing severity of health and or behavior problems associated with diabetes that are seriously affecting their health status. Levels of risk stratification are on a continuously changing basis, depending on the health status of the individual.

The care calls between specially trained nurses and the patient is the primary method of facilitating behavior change of the member towards their disease. Frequency of these care calls is dependent on level of risk stratification: level 1 receives no care calls, level 2 receives a care call every 6 weeks, level 3 receives a care call every 4 weeks, and level 4 receives a care call every 2 weeks. The content of these care calls include, but are not limited to patient education, review of adherence to medication, progress towards establishment of self-care goals, review of adherence to physician treatment plan, or identification of new problems experienced by the member.

Results

Means and standard deviations along with the minimum and maximum values for the sample of 496 individuals are presented in Table 1. The range of the means for the 8 items lay between 3.38 and 3.91, which corresponded to a response of 3 as somewhat and a response of 4 as moderately on the survey. The range of the standard deviations for the eight items was between 1.04 and .85. Care call count had a mean of 5.98 with a standard deviation of 3.73, which indicated individuals had received 6 care calls on average during the duration of the disease management program. The mean for member months was 16.71, with a standard deviation of 2.87. On average, diabetic individuals had been signed up for the disease management program 17 months. The mean for total medical expenditures was 13,544.05 with a standard deviation of 19,970.97, which indicated that the health care company has paid an average $13,544 for each diabetic individual during the duration of the program. Length of stay was 3.56 with a standard deviation of 10.27. Thus, diabetic individuals had spent about 4 days on average in the hospital during the program. The average age for the diabetic individuals enrolled in this program was 59.86 with a standard deviation of 12.84.

A correlation matrix of all the observed variables are presented in Table 2. Because individuals with a response of 1 for any of the 8 items were eliminated, the minimum value for any of the 8 items started at the value of 2. There were a few clusters of high correlations among the 8 items. Item 1 correlated highly with item 5 (r=.53), 6 (r=.69), and 7 (r=.52), which revolved around item 1 of paying attention to medical tests, item 5 of improving taking medical tests, item 6 of more frequently discussing their medical condition, and item 7 of increasing the use of preventative health services (i.e., dental and eye exams). Also, item 5 correlated highly with item 6 with r=.56 while item

Table 1

Means and Standard Deviations of Indicator Variables

Variable	Mean	SD	Minimum	Maximum
Paid Attention to Medical Tests (Q1)	3.91	0.92	2.00	5.00
Improved Eating Habits (Q2)	3.38	0.86	2.00	5.00
Improved Taking Meds (Q3)	3.58	1.04	2.00	5.00
Increased Physical Activity (Q4)	3.40	0.88	2.00	5.00
Frequently Discussed Medical Condition (Q5)	3.63	0.95	2.00	5.00
Improved Taking Medical Tests (Q6)	3.76	0.85	2.00	5.00
Increased Use of Health Services (Q7)	3.63	0.92	2.00	5.00
Spent Less Time Worrying (Q8)	3.42	0.96	2.00	5.00
Current Stratification	2.56	0.66	1.00	4.00
Care Call Count	5.98	3.73	1.00	26.00
Member Months	16.71	2.87	4.00	18.00
Total Medical Expenditures	13,544.05	19,970.97	0	20,5124.71
Length of Stay	3.56	10.27	0	117.00
Health Status	3.24	0.85	1.00	5.00
Age	59.86	12.84	18.00	93.00

6 correlated highly with item 7 with *r*=.47. Among the observed variables, total medical expenditures had a very high correlation with length of stay (*r*=.58), since hospitalization accrues high amounts of medical expenditures.

Exploratory factor analysis revealed a one-factor solution of the 8 items of the Behavior Change Factor. The higher-loading items related to paying closer attention to medical tests (Q1), improving taking recommended medical tests (Q6), more frequently discussing medical conditions (Q5), and increasing the use of preventative health services (Q7). Factor loadings of the 8 items to the Self-perception of Behavior Change factor are presented in Table 3. The range of the factor loadings for the 8 items was between .417 and .816.

The AMOS statistical package was utilized to extract latent structural models from the data set. Chi-square and goodness-of-fit indices were found for all three models, and then modifications were made to the best fitting model to arrive at the final model. However, the solution was not admissible for the Full Mediation Model, even though high fit indices were given from the analysis. A summary of the fit indices for the three proposed models and the final model can be seen in Table 4. Several indices can be examined to discern the validity of each model. The goodness-of-fit index (GFI) indicates how well the model fits the data with higher numbers indicating better model fit. The adjusted goodness-of-fit index (AGFI) gives the accuracy of model fit to the data while accounting for the degrees of freedom. The Root-mean squared error (RMSEA) indicates how much error is in the model, with lower numbers indicating less error. A GFI of .90 and above is desired to indicate good model fit, while a RMSEA of .05 or

Table 3

Factor Loadings of 8-items to Self-perception of Behavior Change Factor

Item	Factor Loading
Paid Attention to Medical Tests (Q1)	0.816
Improved Eating Habits (Q2)	0.524
Improved Taking Meds (Q3)	0.637
Increased Physical Activity (Q4)	0.495
Frequently Discussed Medical Condition (Q5)	0.745
Improved Taking Medical Tests (Q6)	0.804
Increased Use of Health Services (Q7)	0.658
Spent Less Time Worrying (Q8)	0.417

Table 4

Fit Statistics for the Three Proposed Models and Final Model (N=496)

Model	df	χ^2	χ^2/df ratio	GFI	AGFI	ECVI	RMSEA
No Behavior Effect Model	19	141.478	7.446	.937	.880	.355	.114
Partial Mediation Model	99	283.364	2.862	.935	.910	.722	.061
Full Mediation Model	102	312.375	3.063	.927	.902	.768	.065
Final Model	88	215.833	2.453	.946	.926	.565	.054

Note: GFI=Goodness-of-Fit, AGFI=Adjusted Goodness-of-Fit, ECVI=Expected Cross-Validation Index, RMSEA=Root Mean Square Error.

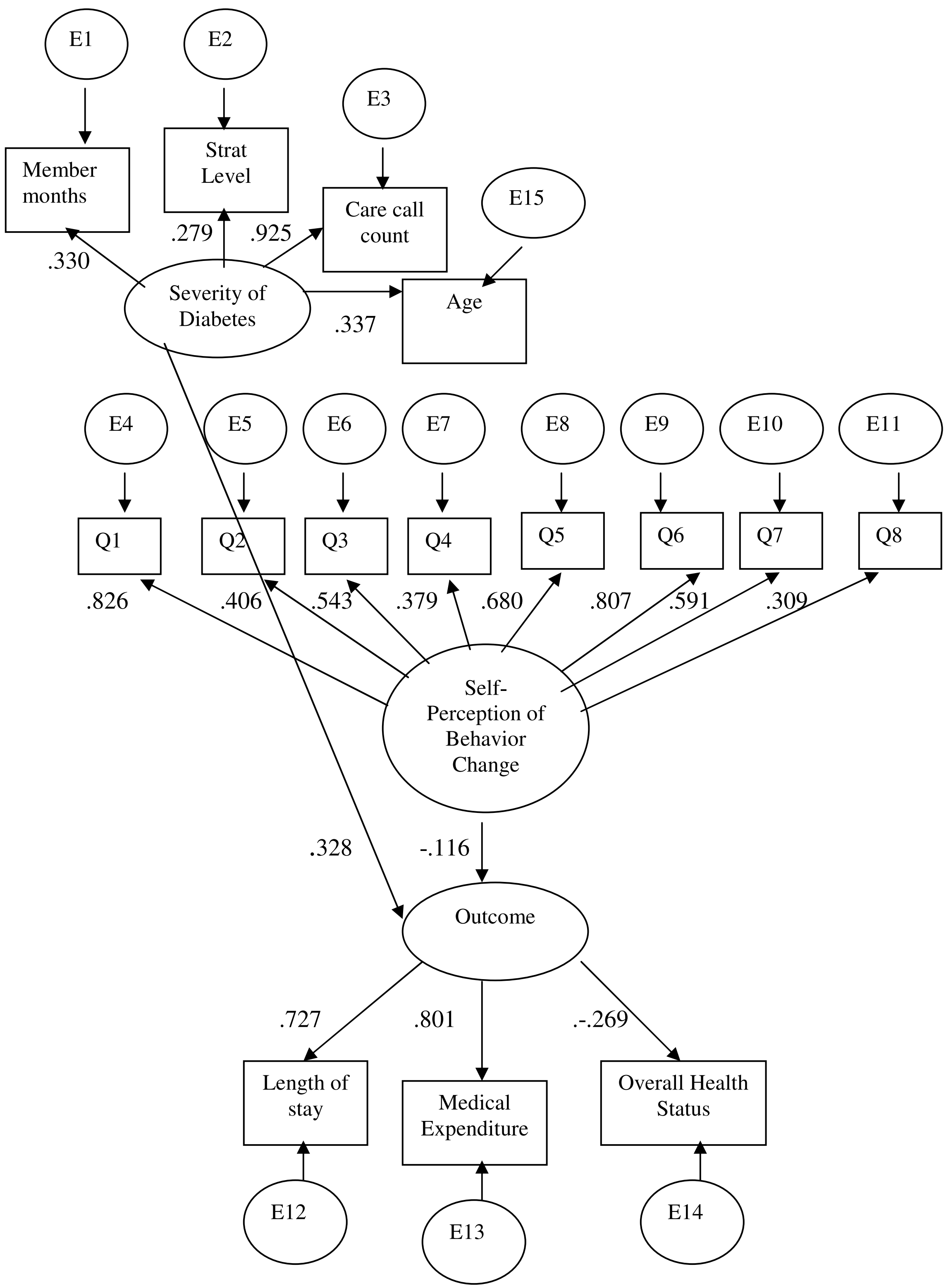
below is desired to indicate low error in the model.

Chi-square difference tests were performed between the No Behavior Effect Model and Partial Mediation Model as well as between the Partial Mediation Model and Full Mediation Model. A significant result indicates that the two models are significantly different. The chi-square difference test between the No Behavior Effect Model and the Partial Mediation Model showed a significant difference, χ^2(80, N=496)=141.886, $p<.05$, indicating the addition of the behavior component in the Partial Mediation Model significantly improved the model-data fit. The chi-square difference test between the Partial Mediation Model and the Full Mediation Model was significant, χ^2(3, N=496)=29.011, $p<.05$, showing the addition of the paths between the Severity of Diabetes, Age, and Gender factors to the Outcome factor in the Partial Mediation Model significantly increased the model-data fit.

Steps to Achieving the Final Model

In addition to testing the significance of each model and the difference between models, the best model for the given data set was perused with the AMOS modification procedure. Of the three proposed models, the best fitting model (Partial Mediation Model) was altered by deleting any nonsignificant paths and observed variables indicated by the modification indices to arrive at a final model. The Final Model can be seen in Figure 6, along with the standardized coefficients. Gender did not have any influence on the Self-Perception of Behavior Change factor or the Outcome factor, and thus was eliminated from the model. Also, the paths between the Age manifest variable to the Self-perception of Behavior Change factor and the Outcome factor were eliminated due

Figure 6. Final Model with standardized coefficients. Latent constructs are shown in ellipses, indicator variables are shown in rectangles, and error terms are shown in circles.



to nonsignificance. Finally, due to nonsignificance, the path between the Severity of Diabetes factor and the Self-perception of Behavior Change factor was eliminated. However, the modification indices indicated a high significance between Age and the Severity of Diabetes factor, so a path was created between the observed variable Age, and latent factor Severity of Diabetes. The Final Model resulted in the influence of two latent factors (Severity of Diabetes factor and Self-perception of Behavior Change factor) on the Outcome factor.

Looking at the indicator variable, Age had a positive correlation with Severity of Diabetes (r=.337), so that older diabetic individuals have higher levels of severity of diabetes, as has been found in past research (Gonnella, Hornbrook, & Louis, 1984). Care call count had the most significant, positive relationship to severity of diabetes (r=.925), indicating higher numbers of care calls received is associated with higher severity of diabetes.

The Self-perception of Behavior Change factor had the highest loadings from the items pertaining to medical tests including paying attention to medical tests (Q1) (r=.826) and improving receiving the appropriate medical tests (Q6) (r=.807). Finally, length of stay in hospital and medical expenditures had positive correlations to the Outcome factor, meaning that higher length of stay (r=.727) and medical expenditures (r=.801) is associated with higher outcomes. But, health status had a negative correlation with outcome (r=-.269), showing that the higher the health status, the healthier the individual, the lower the outcome, or medical expenditure.

Discussion

There has been little previous research on the influence of behavior toward the management of diabetics and how behavior influences different outcomes for diabetics. This study has been one of the first studies to approach the development of a model to include and help explain the behavioral component in a diabetes disease management program.

Three structural models were proposed to explain a possible latent structure of the data set. The No Behavior Effect Model does not include the behavior component, but only had the influence of the Severity of Diabetes factor, Age, and Gender on the Outcome factor. The GFI is good, but there is some error in the model due to a high RMSEA value. The Full Mediation Model contains the Self-perception of Behavior Change factor, with the influence of severity of diabetes on the behavior change component, which in turn influences the Outcome factor. The model fit of the Full Mediation Model is better than that of the No Behavior Effect Model, but again there is some error associated with the model due to a high RMSEA value and a solution that was not admissible. The Partial Mediation Model is the best fitting model to the data of all three models with a good GFI in addition to smaller error term, or lower RMSEA value. The influence of severity of diabetes, age, and gender on the behavioral component as well as the Outcome factor provides the best model-data fit.

The structural models from the current data set reveal high values of GFI (range of .927 to .937) with low RMSEA (range of .114 to .061). The GFI indices are higher than that of Nowacek et al. (1990) with a GFI of .845. Additionally, all RMSEA indices from the current models except the No Behavior Effect Model (.114) are lower than that of Nowacek et al. (.074). Except for the No Behavior Effect Model, all structural models including the Final Model better explain diabetes disease management than that of Nowacek et al.

Due to the significant result of the chi-square difference test between the No Behavior Effect Model and the Full Mediation Model, the addition of the behavioral component is found to be statistically significant in explaining outcomes in the diabetes disease management program. Because of the significance of the chi-square difference test between the Partial Mediation Model and Full Mediation Model, severity of diabetes, age, and gender along with the behavior component best explain the outcomes in diabetics.

The Final Model is not a mediating model as previously thought, but actually the influence of two latent factors (Severity of Diabetes and Self-Perception of Behavior Change factors) on the Outcome factor. Behavior has an independent effect on outcomes but does not mediate the severity of diabetes. The Self-perception of Behavior Change factor has a negative correlation to Outcome, so that higher perceptions of behavior change towards the management of diabetes is associated with lower medical expenditures. This finding may reveal significant implications to the relationship between behavior change factor and medical expenditures. It proves that behavior change plays an important role in reducing medical expenditures. Specifically, the more behavior changes towards managing diabetes, the less medical expenditures and hospitalization diabetics' accrue and the higher their overall health status. Additionally, Severity of Diabetes has a positive correlation with the Outcome factor, indicating more severe diabetics have higher medical expenditures.

However, severity of diabetes did not have a significant relationship to behavior change due to a nonsignificant path, as indicated in the modification indices. It would seem that the more severe the diabetes, the more the behavior change would occur, especially since more severe diabetics receive more care calls from trained nurses. Taking the Hawthorne effect into consideration, it would appear diabetics that are constantly reminded about managing diabetes (one care call every two weeks for diabetics in risk stratification level four) would change their behavior to manage their diabetes more. But, this was not the case.

Due to practical limitations of using an archival data set, this model only includes a small number of observed variables. Additional variables may exist that better explain the effect of behavior change in a diabetes disease management program on outcomes. Personality and individual difference variables may account for degree of behavioral change better than severity of the illness. The model was developed and tested from pre-determined variables based on an archival data set, instead of testing a model based on a pre-designed model. Also, the final model was data driven, since changes were made to the original model in order to find the best fitting model based on the current data set. Unfortunately, cross-validation is not possible due to a small sample size.

Future studies involving a behavior change component in diabetes disease management may explore a means to overcome limitations of this project. First, an appropriate model may be developed based on all relevant variables, and then data collection will take place to test the model. A well-developed model based on the appropriate variables relating to diabetes should provide good fit from data collected from a diabetic sample. Developing the model before data collection allows the researcher to include all important and relevant variables that are necessary for producing a good theory-based model, although this procedure requires considerable amount of time and energy.

Conducting cross-validation may also improve the validity of the model. While proposing a model with only one sample gives a weak model, cross-validation with one large data set split into two sub-samples provides a strong and valid model.

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Appendix 1: Self-Perception of Behavior Change Survey

Self-Perception of Behavior Change Survey

Rating Scale: 1=Not applicable or Don't Know

2=Not At All

3=Somewhat

4=Moderately

5=A lot

As a result of participating in the diabetes disease management program, to what extent have you:

1. Paid closer attention to the results from your medical tests (e.g., blood pressure, DRE, (HbA_{1C}, Cholesterol Screening, etc.)?
2. Improved your eating habits?
3. Improved on taking your medications as prescribed?
4. Increased your physical activity (e.g. walking, playing sports, physical leisure activities)?
5. More frequently discussed your medical condition(s) with your doctor?
6. Improved on taking recommended medical tests on time (e.g., blood pressure, DRE, (HbA_{1C}, Cholesterol Screening, etc.)?
7. Increased your use of preventative health services (e.g., yearly physicals, dental visits, scheduled doctor appointments)?
8. Spent less time worrying about your medical condition?

Appendix 2: Permission Letter from American Healthways

Appendix 3: IRB Approval Letter